AGRICULTURAL ENERGY CENTRE

HANDLING AND CURING
PEANUTS
IN MODIFIED TOBACCO BINS

REPORT NO. 89-5104 June, 1989

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ABSTRACT

The objective of this demonstration project was to determine if tobacco curing bins can be modified for handling and curing of Ontario grown peanuts. Peanuts were loaded into modified tobacco curing bins, placed in a tobacco bulk kiln and cured. Compared to present methods used for handling and curing of peanuts, the bin method has potential for reducing handling costs. But before this method can be recommended to growers, further modifications to the bins are necessary to prevent air from channelling between the bins during curing.

INTRODUCTION

Curing "Ontario" grown peanuts in existing bulk tobacco kilns is cost-effective. Only minor modifications are required to the structure and operation of these kilns to accommodate peanut curing. Utilizing kilns as peanut dryers eliminates the need to purchase specialized drying equipment and also increases the usefulness of these kilns. A disadvantage associated with using tobacco kilns for curing peanuts is that conveyors and manual labour are required for handling the pods into and out of the kilns.

Once-over harvesters are utilized to dig the majority of peanuts grown in Ontario. The transition phase between harvesting and curing requires that the peanut pods be unloaded from the once-over harvester into a gravity wagon which is then transported to a tumble washer. The pods are unloaded from the wagon onto a conveyor which leads into the tumble washer. Soil and plant residue among the pods are removed by water sprayed under high pressure. After the pods have gone through the washer they are conveyed to the inside of a bulk kiln using a telescoping conveyor, as illustrated in figure 1. As the pods fall off the end of the conveyor they are distributed over the perforated floor of the kiln up to a depth of 650 mm.

The length of time required to load the pods into a kiln is dependent on the harvesting rate, however, it usually requires 2 people about 4 hours. After curing, the pods are either unloaded using a belt conveyor and shovels or with a pneumatic conveyor. It takes 1 person about 2 to 3 hours to unload the pods using the pneumatic conveyor whereas with the belt conveyor and shovels it requires 2 people from 4 to 6 hours.

In cooperation with the Canadian Peanut Growers' Co-operative Inc., the Agricultural Energy Centre of the Ontario Ministry of Agriculture and Food conducted a project to determine if tobacco curing bins can be modified for handling and curing of peanut pods in tobacco kilns. The project was initiated in the fall of 1987 and completed the following year.

Successful handling and curing of peanuts in bins would reduce peanut growers' capital expenses. Conveyors would not have to be purchased, energy input required to operate conveyors would be eliminated and labour input

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The mention of manufacturer's trade names is for the purpose of specific product description and does not indicate endorsement or criticism of that product or products not mentioned by the author or the Ontario Ministry of Agriculture and Food.

associated with handling pods into and out of kilns would be reduced.

OBJECTIVES

The objective of the project was to determine if tobacco curing bins can be used for the handling and curing of peanut pods in tobacco kilns. The applicability of using this proposed handling/curing method was evaluated by determining:

i.) the degree of modifications required to the bulk kiln to accommodate bins filled with peanut pods;

ii.) the degree of modifications required to convert tobacco curing bins for containing peanut pods;

iii.) product handling requirements with bins as compared to present methods used by the majority of the peanut industry;

iv.) differences in the curing process resulting from peanut pods being contained in bins rather than loose on the perforated floor of the bulk kiln;

v.) dried quality of peanuts cured in bins as compared to loose on the perforated floor of a bulk kiln;

vi.) differences in the amount of energy required to cure peanuts in bins as opposed to loose on the floor of a bulk kiln.

METHOD

Bin Modifications

In 1987, 7 "DeCloet" tobacco bins, as illustrated in figure 2, were modified to contain peanut pods for curing. Instead of using the bins in the upright position, the manner in which they are used for tobacco, the bins were modified so that they could be used in the horizontal position (with the gate openings on top of the bin). Casters on the bottom of the bins were removed and welded onto each corner on the side opposite the gates on the bins. The longest sides of the bins were fitted with 12 mm plywood and the bottom of the bins with metal screening. The side of the bin that would butt against the side of another bin in the kiln was fitted with a foam gasket to prevent curing air from channelling between the bins. The last modification was to remove the gates from the top of the bin.

The cost to buy and modify the 7 tobacco curing bins totalled $1948. A breakdown of the costs follows:

(7) Tobacco Bins*	$1000
Plywood	$ 220
Screens	$ 285
Bolts & Screens	$ 11
Labour (72 h @ $6.00/h)	$ 432
Total	$1948

*If kilns are already equipped with curing bins this cost would be eliminated.

Bulk Kiln Specifications and Modifications

In 1987, 3, 180 rack size, "DeCloet" kilns were selected for the project. These kilns had previously been converted to accommodate full-size tobacco curing bins. One of the kilns was modified to accommodate the modified bins. The 2 metal rails on the interior walls of the kiln, used for guiding the bins during loading and also to prevent air from channelling between the ends of the bins and side walls of the kiln during tobacco curing, were repositioned to about one-half the height of the modified bins. The objective of this modification was to have the metal rails serve the same purposes as they do for tobacco curing. Figure 3 illustrates the modified bins loaded with peanut pods in the kiln.

One of the kilns was to be loaded with the 7 bins of peanut pods while the other 2 kilns, which would serve as check kilns, were to be loaded with peanut pods directly onto the perforated floor of each kiln. Loading of the pods into the kilns would occur on a daily basis. One of the check kilns would be loaded on the first day, on the next day the bins would be filled and loaded into the modified kiln and then on the third day the other check kiln would be loaded.

Unfortunately problems were encountered when the kilns were loaded and again during curing. Mechanical problems with the once-over harvester resulted in each of the 3 kilns being loaded over 2 to 3 day period. Problems were also encountered, during curing, with the operation of the burner in the bin loaded kiln. The burner did not fire properly during the initial 2 days of curing. In addition, the datalogger used to record the curing air temperature and relative humidity in the 3 kilns malfunctioned prior to curing and resulted in no data being recorded for the curing period.

Thus the project was carried over to the 1988 year.

It should be noted that even though there were numerous problems encountered during the first year of the project, it did appear that peanuts could be cured successfully in bins. Based on observations made during the curing period for each of the 3 kilns, peanuts which were cured in the bins required a longer drying time (which may have been a result of the malfunctioning burner) but appeared to have the same dried quality as peanuts cured in the check kilns.

In 1988, the project was conducted at a different farm site. The bulk kilns on this farm are of the "DeCloet" type that have a capacity of 162 racks each. Similar to the bulk kilns chosen in 1987, these kilns had also been previously converted to accommodate full-size tobacco curing bins. Three of the kilns at this site were selected for the project. Two of the kilns (kiln #1 and kiln #3) were used as checks while the other kiln (kiln #2) was used for the bins. Modifications to accommodate the bins in kiln #2 were similar to those undertaken at the 1987 site.

The inside dimensions of each kiln's curing compartment are 10780 mm (length) x 3070 mm (width). Height of each kiln's curing compartment is 2400 mm (measured from the perforated floor to the eave of the kiln). The furnace unit of each kiln is equipped with a "Delhi Industries, Model 425" centrifugal blower powered by a 5.6 kW, single phase electric motor. The blower is rated at 7200 L/s @ 470 Pa (kiln manufacturer's rating).

The burner of each kiln is direct-fired and fuelled with natural gas. The fuel energy input of each burner is rated at 411 MJ/h.

Each kiln is insulated in the roof and sidewalls with 25 mm thick expanded polystyrene and 75 mm thick fiberglass batts, respectively.

Loading Procedure

The modified bins were loaded into the modified kiln with either a forklift truck or a bin stand. During the first year of the project the former was used and during the second year of the project the latter was used. When the bin stand was used, an empty bin was placed on the stand and washed peanut pods were dumped from a gravity wagon into the bin. When the bin was full, it was then rolled into the kiln.

Since the kilns used to conduct the test in 1988 were shorter in length than the 180 rack capacity kilns used in 1987, only 6 bins could be loaded into the kiln. Similar to the project design used in 1987, the check kilns selected for the test in 1988 were loaded with peanut pods in the normal manner, that is directly on the perforated floor of the kiln.

The modified bins were used twice to cure peanut pods. The first set of cures involved all 3 bulk kilns. One check kiln was loaded the day before the bin kiln was loaded and the other check kiln was loaded the day after the bin kiln was loaded. For the second set of cures, only one of the check kilns was used and it was loaded the day before the bin kiln was loaded.

Curing Procedure

The curing procedure used was similar for all kilns. After the peanut pods had been loaded into the kiln the blower and burner were turned on. The thermostat was set at 30°C and remained at this setting during the entire curing process. During the initial stage of curing the return air inlet of the furnace unit was blocked and the fresh air damper on the furnace unit was removed to allow as much air to enter the furnace unit as possible. The loading doors of the kiln were left open during this stage so that once the curing air had passed through the peanut pods it was expelled from the loading end of the kiln.

The next stage in the curing process was to re-open the return air inlet of the furnace unit and close the loading doors when the peanut kernels began to rattle in the pods. Re-opening the return air inlet of the furnace unit allows the majority of the curing air within the kiln to be recirculated. The fresh air damper remained open so that the kiln would be positively pressurized to force a portion of the curing air (containing moisture picked up from the peanuts) out through the exhaust louvres located above the loading doors of the kilns. When the moisture content of the peanut kernels reached 10% (w.b.) or less the burner unit was turned off while the blower remained on until the peanuts had cooled to ambient temperature.

After curing was completed, the pods in the check kilns were unloaded using a pneumatic conveyor. The initial plan was to unload the pods from the bins with a tractor-mounted fork lift. The bins would be raised with the forklift over a truck box and tipped to allow the pods to fall into the truck box. However, since it was not known if peanuts could be cured

successfully in bins, the required modifications for this type of unloading were not undertaken.

MONITORING

In order to determine the applicability of using former tobacco curing bins to cure peanuts, the following parameters were monitored during cures in the bin loaded kiln and the check kilns.

i.) initial and final moisture contents of the peanut kernels were determined using an oven dry method of 130°C for 7 hours;

ii.) air flow through the peanut pods was measured using an "Alnor Balometer";

iii.) K-type thermocouples and a "Kaye Digistrip III" datalogger were used to determine the dry-and wet-bulb temperatures of the curing air and the temperature gradient throughout the layer of peanut pods;

iv.) "Rockwell, model RC-415" gas meters were used to record natural gas consumption;

v.) A "Hioki" digital clamp tester was used to measure the voltage and amperage of the motor operating the blower in each kiln.

RESULTS AND EVALUATION

Curing Data

Figure 4 is a summary of the data collected from cures in the check kilns and bin loaded kiln. For the first set of cures the total volume of green peanut pods loaded into the 6 bins was 16.92 m^3 which was about 4 m^3 less than the volume of peanut pods loaded in kiln #1 and about 3.5 m^3 less than the volume of peanut pods loaded in kiln #3. For the second set of cures the volume of green peanut pods in the bin loaded kiln and kiln #3 was 20.04 m^3 and 19.57 m^3, respectively.

The initial moisture content (w.b.) of the peanut pods cured ranged from 62% to 71% for the 2 sets of cures. The peanut pods in the bin loaded kiln and kiln #3 were at identical moisture contents for both sets of cures.

The length of time required to cure the peanuts in the bin loaded kiln was 205 h for the first cure and 216 h for the second cure. During the first set of cures, peanuts in kiln #1 were cured in 189 h while the peanuts

in kiln #3 were cured in 202 h. There was a significant difference in the amount of time required to cure the peanuts in the bin loaded kiln as compared to kiln #3 for the second set of cures. Peanuts in the bin loaded kiln required about 67 h longer to cure than in kiln #3. The dried moisture content (w.b.) of the peanuts cured in the kilns ranged between 8 and 10%.

The drying rate (% moisture content loss per hour or % m.c./h) for the first set of cures was similar for all kilns and ranged between 0.27 and 0.30% m.c./h. However, the drying rate recorded for the second set of cures was significantly lower for peanuts cured in the bin loaded kiln than in kiln #3. The drying rate was 0.38% m.c./h for peanuts cured in kiln #3 as compared to 0.27% m.c./h for peanuts cured in the bin loaded kiln.

The shrinkage in the volume of the peanut pods as a result of curing was also recorded. Overall, the volume of the green peanut pods decreased by 15 to 21% as a result of curing. There does not appear to be any significant difference in shrinkage between the peanuts cured in the bin loaded kiln and the check kilns.

Curing Air Temperature and Relative Humidity

Figures 5 to 9 show the dry-bulb temperature and relative humidity of the curing air recorded during each cure in the kilns. During the initial stages of curing in each kiln, when no air was recirculated to the furnace unit, there was a noticeable fluctuation in the temperature of the curing air and to a lesser extent the relative humidity of this air. The reason for this fluctuation is that the 411 MJ/h burner unit of each kiln is not large enough to raise the temperature of the incoming ambient air to 30°C (thermostat setting) when the ambient air is about 16°C or less. Thus when the temperature of the ambient air was less than 16°C, which it was for the majority of the curing period in the kilns, the burner of each kiln ran continuously and could only increase the temperature of the ambient air by a maximum of 14C°.

When the curing air was recirculated through the furnace unit, during the latter stages of curing, the temperature was relatively constant and similar to the thermostat setting for all of the kilns. The relative humidity of curing air in each of the kilns appeared to rise sharply when air recirculation was started and then afterwards decreased steadily to about 40%.

There does not appear to be any noticeable differences between the curing air temperature and relative humidity of cures in the bin loaded kiln as compared to cures in the check kilns. There does however appear to be a significant difference in the length of time that the curing air was not recirculated in the bin kiln as compared to kiln #3 for the second set of cures. Recirculation of the curing air did not begin in the bin loaded kiln until the after 146 h of curing while in kiln #3 it was after 95 h of curing. This is probably a result of poor airflow through the peanuts in the bin equipped kiln which is explained in detail in the following section.

Airflow Rates

Airflow measurements recorded during the initial stages of curing, when air passes through the peanut pods once and is expelled from the kiln, indicated that more air was going through the pods in check kilns than in the bin loaded kiln for both sets of cures. Figure 10 shows that the for the first set of cures the measured airflow rate of 169 L/s/m^3 of peanut pods in the bin loaded kiln was about 70% to 75% of the airflow rate recorded in the check kilns. For the second set of cures the airflow rate in the bin loaded kiln, 98 L/s/m^3 of peanut pods, was less than half the airflow rate recorded in kiln #3.

During the latter stages of curing, when the majority of the curing air was recirculated to the furnace unit, the airflow rate in the bin loaded kiln was again less than in the check kilns for both sets of cures. The airflow rate in the bin loaded kiln was 294 L/s/m^3 which was about 13% less than the airflow rate in kiln #3 for the first set of cures. During the second set of cures, the airflow rate of 199 L/s/m^3 of peanut pods in the bin loaded kiln was about 46% less than the airflow rate in kiln #3.

When the airflow measurements were being taken, it was evident as to why the airflow through the peanut pods was less in the bin loaded kiln than in the check kilns. There was a considerable amount of air channelling where the bins were butted against one another in the kiln. The foam gasket, used as an air seal between bins, was allowing air to channel between the bins because the bins were not close enough together for the gasket to be effective. When these bins are used for tobacco, a metal bar is positioned parallel to the last bin in the kiln and then tightened against that bin

until all of the bins in the kiln are tightly butted together. If this bar had been used to push the bins of peanuts closer together, the foam gasket on the bins would have been more effective and the air channelling probably could have been prevented.

The low airflow rate recorded for the second cure in the bin loaded kiln probably was responsible for the longer curing time. Even though the airflow rate was lower in the bin filled kiln than in the check kilns for the first set of cures, it appears that it was not significant enough to affect the drying rate.

Curing Energy Consumption and Cost

Figures 11 and 12 indicate that the cost of curing was greater for peanuts cured in the bin loaded kiln than the check kilns for the 2 sets of cures. The cost was 0.08 and 0.09 $ per kg for peanuts cured in the bin kiln as compared to about 0.06 $ per kg for peanuts cured in the check kilns for the 2 sets of cures. The higher cost for peanuts cured in the bin loaded kiln can probably be also attributed to the lower airflow rates through the peanut pods.

Peanut Quality

Peanuts cured in the bin loaded kiln were visually inspected for quality. There was no apparent differences between peanuts cured in the bin loaded kiln and those cured in the check kilns for the first set of cures. However, the peanuts cured in the bin loaded kiln in the second set of cures were badly water marked while peanuts cured in the check kiln also exhibited some water marking but not as severe. Water marking is an indication that the initial drying rate was too slow for the amount of water that needed to be removed from the peanut pods.

CONCLUSIONS

The concept of modifying tobacco bins for the handling and curing of peanuts has potential, however, if air is allowed to channel around the bins of peanut pods during curing it will result in a slow drying rate, increase energy consumption and decrease the quality of the peanuts. An improved method to prevent curing air from channelling around the bins needs

to be devised before the bin method for handling and curing of peanuts can be recommended to growers.

ACKNOWLEDGEMENTS

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Figure 1: Equipment used for washing and conveying peanut pods

Figure 2: "DeCloet" tobacco bin

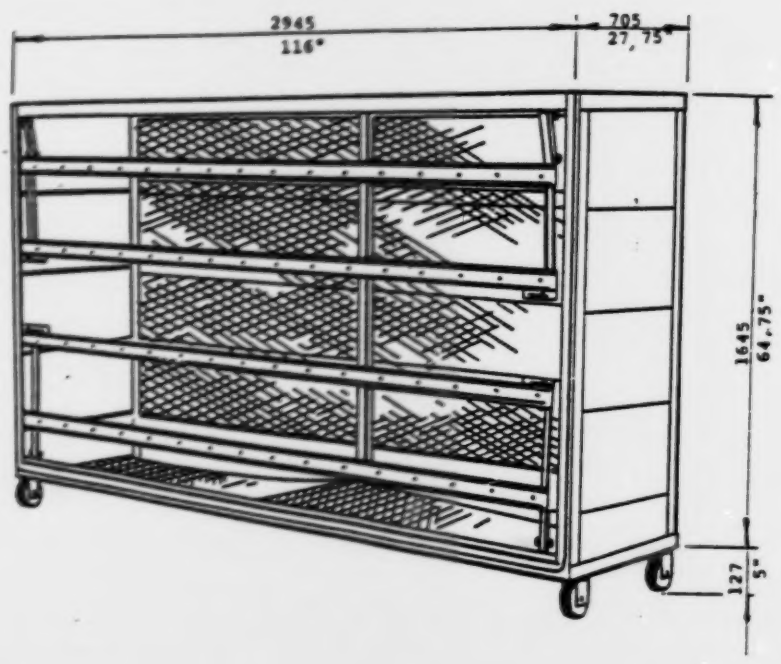

Figure 3: Bins containing peanut pods inside of bulk kiln

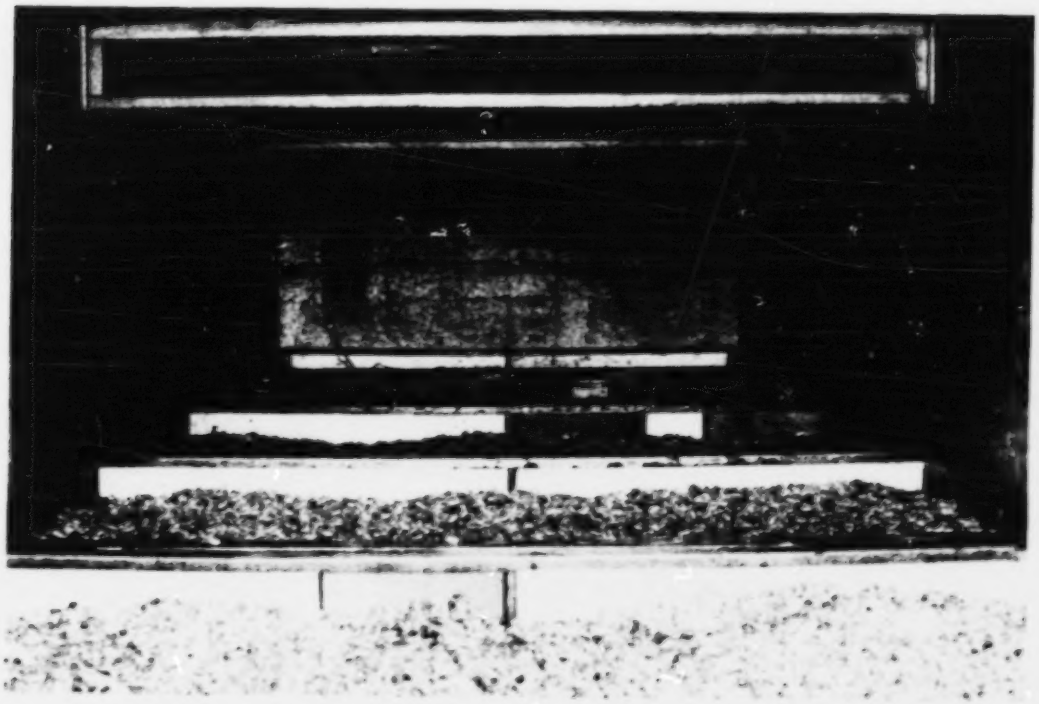

Figure 4: Summary of peanut cures

CURE #	KILN(K) #	MOISTURE CONTENT initial (% w.b.)	MOISTURE CONTENT final (% w.b.)	FINAL MASS (kg)	CURE LENGTH no-recirc.* (h)	CURE LENGTH recirc.** (h)	CURE LENGTH total (h)	RATE OF DRYING (%m.c./h)	PEANUT POD VOLUME initial (m^3)	PEANUT POD VOLUME final (m^3)	PEANUT POD VOLUME shrinkage (%)
SET 1 CURES											
	K1(check)	61.62	9.90	3281	73.0	115.8	188.8	0.27	21.05	17.80	15.4
	K2(bin)	70.44	8.10	2300	62.9	142.0	204.9	0.30	16.92	13.46	20.5
	K3(check)	70.44	9.75	2994	59.6	141.9	201.5	0.30	20.40	16.59	18.7
SET 2 CURES											
	K2(bin)	66.07	8.61	2905	146.5	69.3	215.8	0.27	20.04	16.36	18.4
	K3(check)	66.07	9.16	3031	95.9	52.5	148.4	0.38	19.57	16.63	15.0

*length of time curing air was not recirculated in kiln

**length of time the majority of curing air recirculated in kiln

Figure 5: Curing History– kiln #1 (check), cure 1

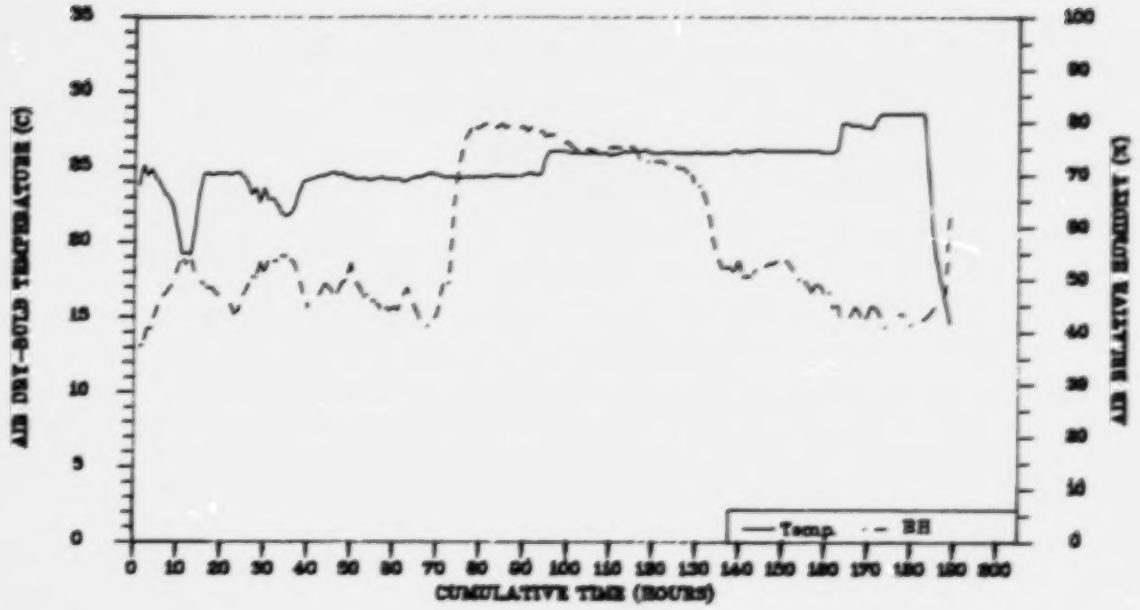

Figure 6: Curing History– kiln #2 (bin), cure 1

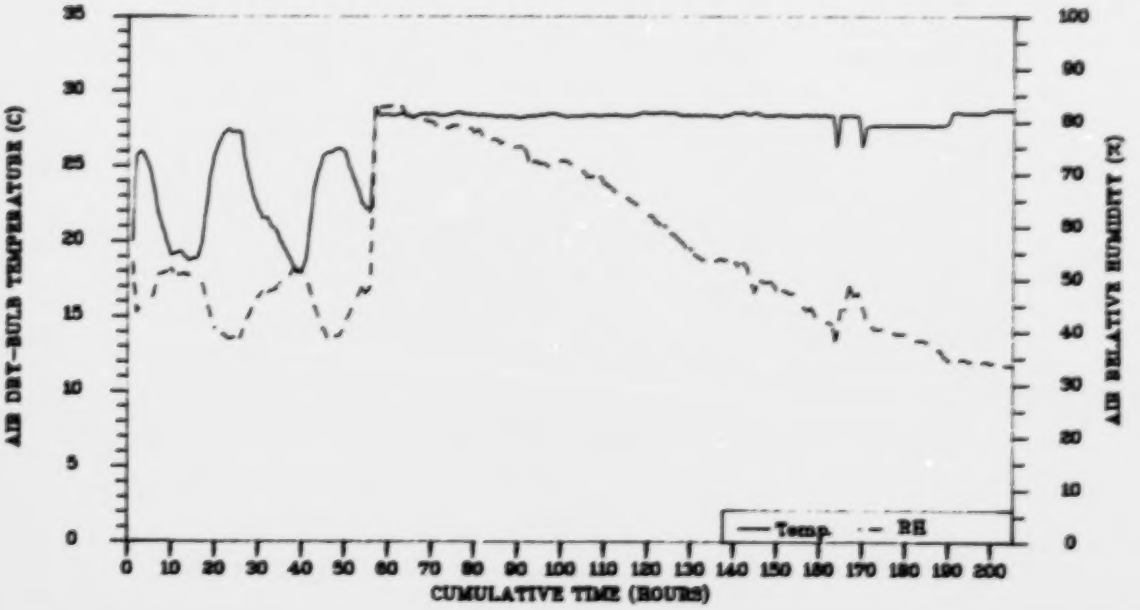

Figure 7: Curing History– kiln #3 (check), cure 1

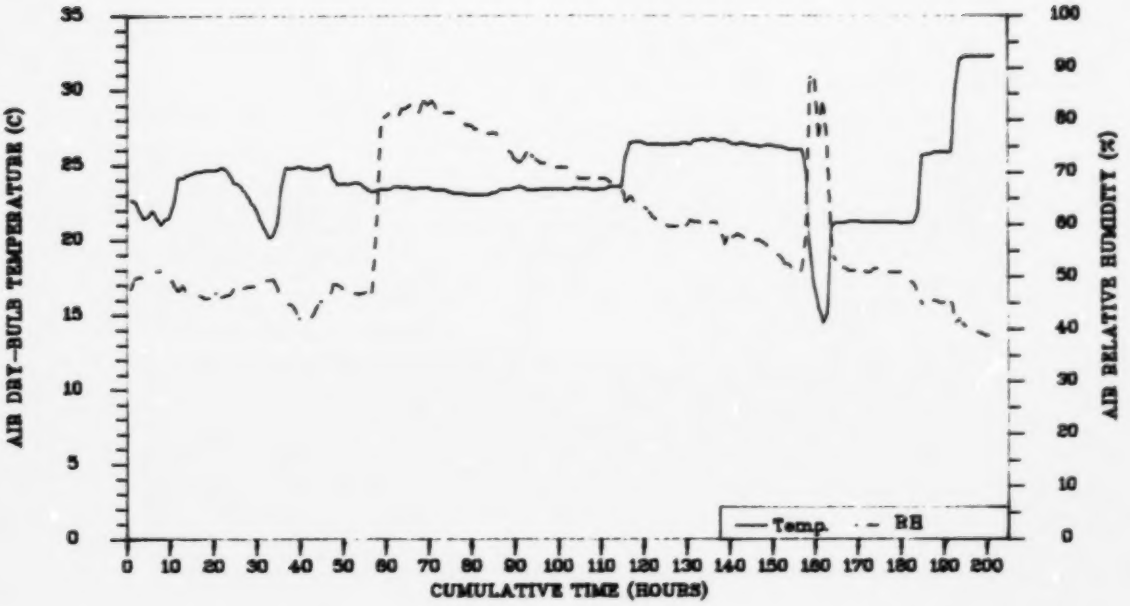

Figure 8: Curing History– kiln #2 (bin), cure 2

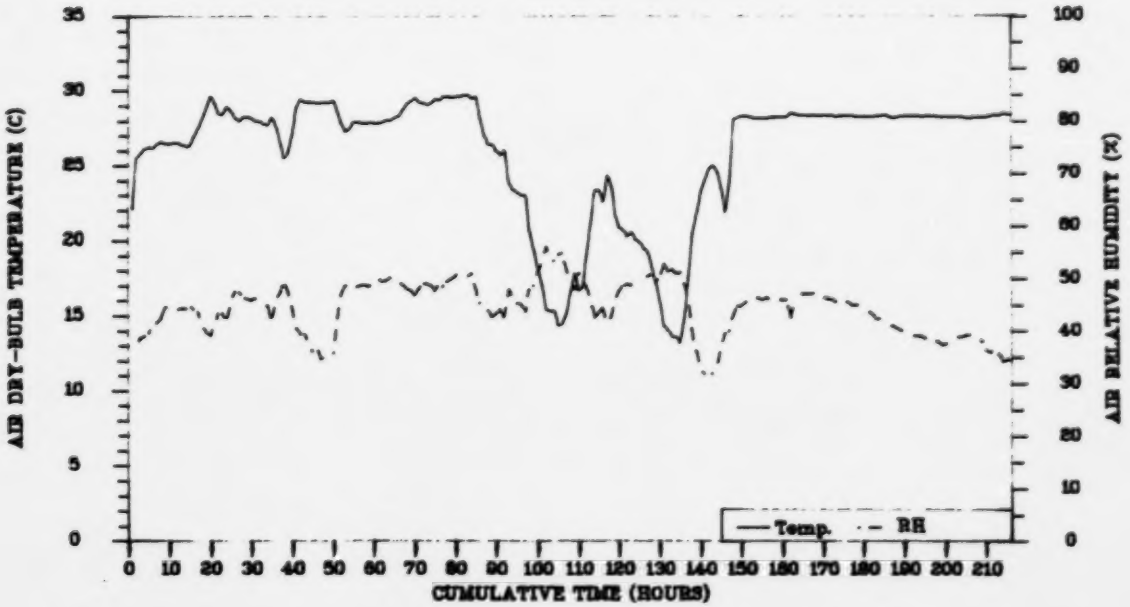

Figure 9: Curing History– kiln #3 (check), cure 2

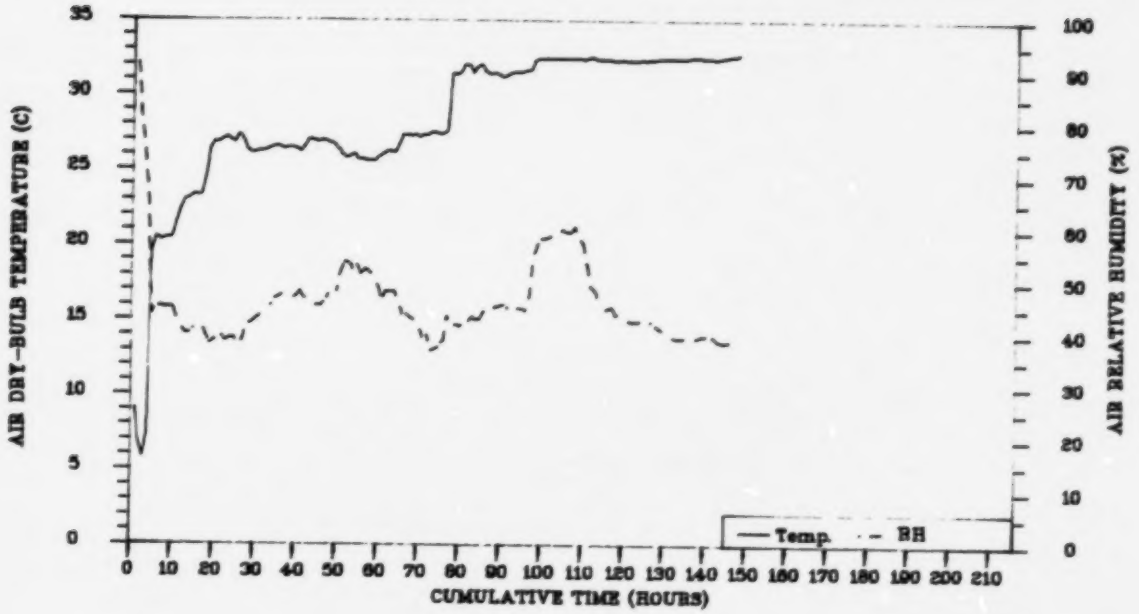

Figure 10: Airflow rates recorded during peanut curing

CURE #	KILN #	AIRFLOW RATE* NO-RECIRC.** (L/s/m³)	AIRFLOW RATE* RECIRC.*** (L/s/m³)
SET 1 CURES			
	K1 (check)	227	N/R
	K2 (bin)	169	294
	K3 (check)	237	337
SET 2 CURES			
	K2 (bin)	98	199
	K3 (check)	264	369

*An "Alnor Balometer" was used to measure airflow. The balometer covers an area of about 350 mm x 350 mm and measures velocity with a set of pitot tubes. The meter is calibrated to indicate the result as an airflow rate in cubic feet per minute. The balometer was placed on top of the peanut layer in each of the kilns and the airflow exiting the peanut layer was recorded and then converted to litres per second.

**Airflow measured when no air was recirculating to furnace unit

***Airflow measured when majority of air was recirculating to furnace unit.

Figure 11: Summary of peanut curing energy consumption

CURE #	KILN #	NATURAL GAS (m^3)	ELECTRICITY (kWh)	TOTAL ENERGY* (MJ)	WATER REMOVED (kg)	ENERGY USEAGE PER H_2O REMOVED (MJ/kg)
SET 1 CURES						
	K1 (check)	943.08	794	38413	4422	8.69
	K2 (bin)	920.42	750	37400	4852	7.71
	K3 (check)	894.93	875	36889	6146	6.00
SET 2 CURES						
	K2 (bin)	1435.85	638	56428	4920	11.47
	K3 (check)	948.74	507	37593	5083	7.40

*37.7 MJ/m^3 natural gas and 3.6 MJ/kWh electricity

Figure 12: Summary of peanut curing energy costs

CURE #	KILN #	NATURAL GAS* ($)	ELECTRICITY* ($)	MASS (kg) dried @ m.c.(w.b.)	TOTAL ENERGY COST PER DRIED MASS ($/kg)
SET 1 CURES					
	K1 (check)	148.63	45.81	3281 @ 9.90%	0.060
	K2 (bin)	145.06	43.28	2300 @ 8.10%	0.082
	K3 (check)	141.04	50.49	2994 @ 9.75%	0.064
SET 2 CURES					
	K2 (bin)	226.29	36.81	2905 @ 8.61%	0.091
	K3 (check)	149.52	29.25	3031 @ 9.16%	0.059

*1988 energy prices = \$0.1576/m^3 natural gas and \$0.0577/kWh for 1-phase electricity